

Having described the invention we claim:

1. A distributed data processing system employing negotiation among autonomous agents for allocation of resources and comprising:
  - a communications network for passing messages between computers connected thereto;
  - a plurality of computers connected to said network for running programs thereon including at least first and second autonomous agents;
  - each said agent receives a graph associated therewith and wherein the graph represents for the associated agent what resources that agent has and what task or tasks that agent may perform and each said agent employs the associated said graph to determine what resource or resources are needed by that agent to carry out the task or tasks to be performed by that agent; and,
  - said agents negotiate with each other for the resources needed to carry out the task or tasks to be performed by said agents.
2. A system as set forth in claim 1 wherein each said agent additionally receives initialization data relating to the associated said graph.
3. A system as set forth in claim 2 wherein each said agent determines whether said initialization data has been received.

4. A system as set forth in claim 3 wherein if the determination is affirmative, then the agent sets up an internal representation respecting the initialization data.

5. A system as set forth in claim 4 wherein said graph is a PN graph and said representation is a PN representation and each said agent calculates deadlock avoidance structures relating to said PN representation and graph.

6. A system as set forth in claim 4 wherein each said agent receives cost data representing cost and task completion rewards.

7. A system as set forth in claim 6 wherein each said agent determines whether said cost data has been received.

8. A system as set forth in claim 7 wherein each said agent forwards update data to a central authority and wherein said update data represents local connections and dependencies.

9. A system as set forth in claim 8 wherein each said agent additionally forwards additional update data to said central authority wherein said additional update data also includes data representing remaining resources and task status.

10. A system as set forth in claim 9 wherein each said agent calculates desired output offer costs.

11. A system as set forth in claim 10 wherein each said agent forwards outgoing offers of resources to other agent or agents.

12. A system as set forth in claim 11 wherein each agent determines whether any additional resource or resources are needed for task completion by that agent.

13. A system as set forth in claim 12 wherein each agent calculates desired resource bid cost if any additional resource or resources are needed.

14. A system as set forth in claim 13 wherein each said agent forwards outgoing bids for resources to the other agent or agents.

15. A system as set forth in claim 14 wherein each said agent receives incoming offers of resources from the other agent or agents.

16. A system as set forth in claim 15 wherein each said agent receives data representing incoming bids from the other agent or agents seeking additional resource or resources.

17. A system as set forth in claim 16 wherein each said agent determines whether there are any acceptable offers or bids from the other agent or agents.

18. A system as set forth in claim 17 wherein each said agent making an affirmative determination respecting acceptable offers or bids and forwards an outgoing acceptance.

19. A system as set forth in claim 17 wherein each agent that determines that there are no acceptable offers or bids receives incoming acceptances from the other agent or agents.

20. A system as set forth in claim 19 wherein each agent determines if any more resources are required for task completion by that agent.

21. A system as set forth in claim 20 wherein each agent that no longer needs resources searches the associated graph for a path for task completion and then completes that task.

22. A method operative in a distributed data processing system employing negotiation among autonomous agents for allocation of resources and employing a communications network for passing messages between computers connected thereto and wherein said computers are operative to run programs thereon including a central authority and at least first and second autonomous agents comprising the steps of:

each said agent receiving a graph associated therewith and representing for that agent what resources that agent has and what task or tasks that agent may use the resources for;

each said agent employing the associated said graph for determining what resource or resources are needed by that agent to carry out the task or tasks to be performed by that agent; and,

said agents negotiating with each other for the resources needed to carry out the task or tasks to be performed by said agents.

23. A method as set forth in claim 22 wherein the step of receiving a said associated graph includes the step at each agent of receiving initialization data relating to the associated said graph.

24. A method as set forth in claim 23 including the step of determining if said initialization data has been received and if so setting up an internal representation based on said initialization data.

25. A method as set forth in claim 24 wherein said representation is an internal PN representation.

26. A method as set forth in claim 25 including the step at each agent of calculating deadlock avoidance structures based on said PN representation.

27. A method as set forth in claim 24 including the step of receiving cost data and determining whether the cost data has been received and if so then forwarding updated data to a central authority with said updated data including data representing local connections and dependencies.

28. A method as set forth in claim 27 wherein said step of forwarding said updated data includes additional updated data representing the remaining resources and task status.

29. A method as set forth in claim 28 including the step at each agency of calculating the desired output offer cost and forwarding outgoing offers to the other agent or agents.

30. A method as set forth in claim 29 including the steps at each agent of determining whether any additional resources are needed to complete the task by that agent and if so calculating desired resource bid costs.

31. A method as set forth in claim 30 including the step of forwarding outgoing bids for resources to the other agent or agents.

32. A method as set forth in claim 31 including the steps at each agent of receiving incoming offers of resources and bids seeking additional resources from the other agent or agents and then determining at each agent whether any acceptable offers or bids have been received.

33. A method as set forth in claim 32 including the step at each agent of forwarding outgoing acceptances if the determination of whether any acceptable offers or bids is affirmative.

34. A method as set forth in claim 31 including the step at each agent of determining whether any more resources are needed.

35. A method as set forth in claim 34 wherein each agent searches the associated graph for a path for task completion and then completes the task.

36. A computer program product operative in a distributed data processing system employing negotiation among autonomous agents for allocation of resources wherein the system includes a communications network for passing messages between computers connected thereto and wherein said computers are connected to said network for running programs thereon including at least two autonomous agents; and comprising:

first and second autonomous agents, each said agent receives a graph associated therewith and wherein the graph represents for the associated agent what resources that agent has and what task or tasks that agent may use the resources for;

each said agent employs the associated said graph to determine what resource or resources are needed by that agent to carry out the task or tasks to be performed by that agent; and,

said agents negotiate with each other for the resources needed to carry out the task or tasks to be performed by said agents.

37. A system as set forth in claim 36 wherein each said agent additionally receives initialization data relating to the associated said graph.

38. A system as set forth in claim 37 wherein each said agent determines whether said initialization data has been received.



39. A system as set forth in claim 38 wherein if the determination is affirmative, then the agent sets up an internal representation respecting the initialization data.

40. A system as set forth in claim 39 wherein said graph is a PN graph and said representation is a PN representation and each said agent calculates deadlock avoidance structures relating to said PN representation and graph.

41. A system as set forth in claim 39 wherein each said agent receives cost data representing cost and task completion rewards.

42. A system as set forth in claim 41 wherein each said agent determines whether said cost data has been received.

43. A system as set forth in claim 42 wherein each said agent forwards update data to a central authority and wherein said update data represents local connections and dependencies.

44. A system as set forth in claim 43 wherein each said agent additionally forwards additional update data to said central authority wherein said additional update data also includes data representing remaining resources and task status.

45. A system as set forth in claim 44 wherein each said agent calculates desired output offer costs.

46. A system as set forth in claim 45 wherein each said agent forwards outgoing offers of resources to other agent or agents.

47. A system as set forth in claim 46 wherein each agent determines whether any additional resource or resources are needed for task completion by that agent.

48. A system as set forth in claim 47 wherein each agent calculates desired resource bid cost if any additional resource or resources are needed.

49. A system as set forth in claim 48 wherein each said agent forwards outgoing bids for resources to the other agent or agents.

50. A system as set forth in claim 49 wherein each said agent receives incoming offers of resources from the other agent or agents.

51. A system as set forth in claim 50 wherein each said agent receives data representing incoming bids from the other agent or agents seeking additional resource or resources.

52. A system as set forth in claim 51 wherein each said agent determines whether there are any acceptable offers or bids from the other agent or agents.

53. A system as set forth in claim 52 wherein each said agent making an affirmative determination respecting acceptable offers or bids and forwards an outgoing acceptance.

54. A system as set forth in claim 53 wherein each agent that determines that there are no acceptable offers or bids then receives incoming acceptances from the other agent or agents.

55. A system as set forth in claim 54 wherein each agent determines if any more resources are required for task completion by that agent.

